

Experimental Evaluation of Multiphase Fluid-Rock Reactions among Supercritical Carbon Dioxide, Brine, Aquifer, and Caprock: Integrity of a Geologic Carbon Repository

John P. Kaszuba

David R. Janecky

Marjorie G. Snow

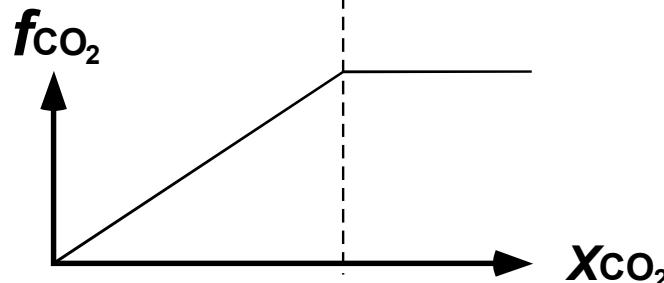
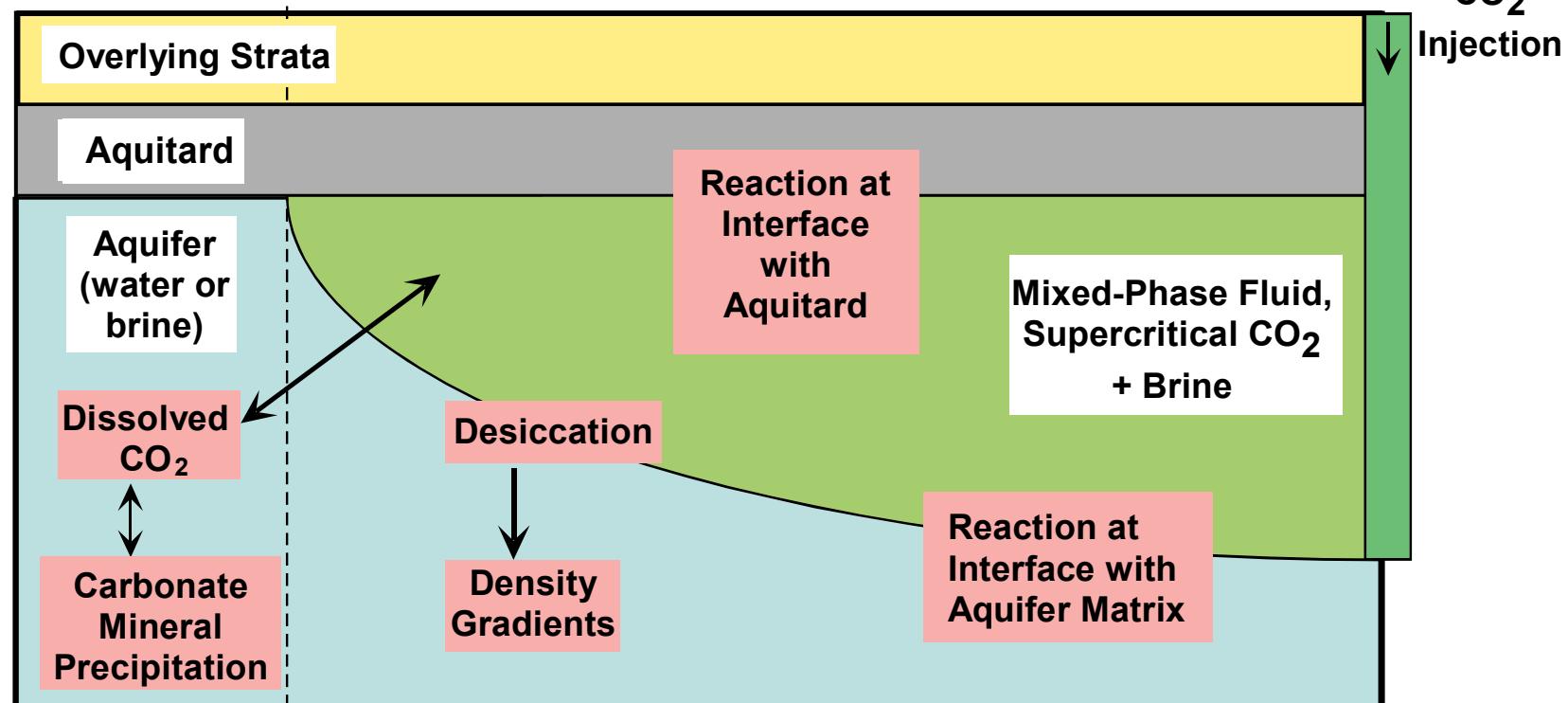
**Los Alamos National Laboratory
Los Alamos, NM 87545**



Background - Geologic Sequestration of CO₂

Geochemical Processes
Reported in
Literature

Geochemical Processes
Suggested by this Study



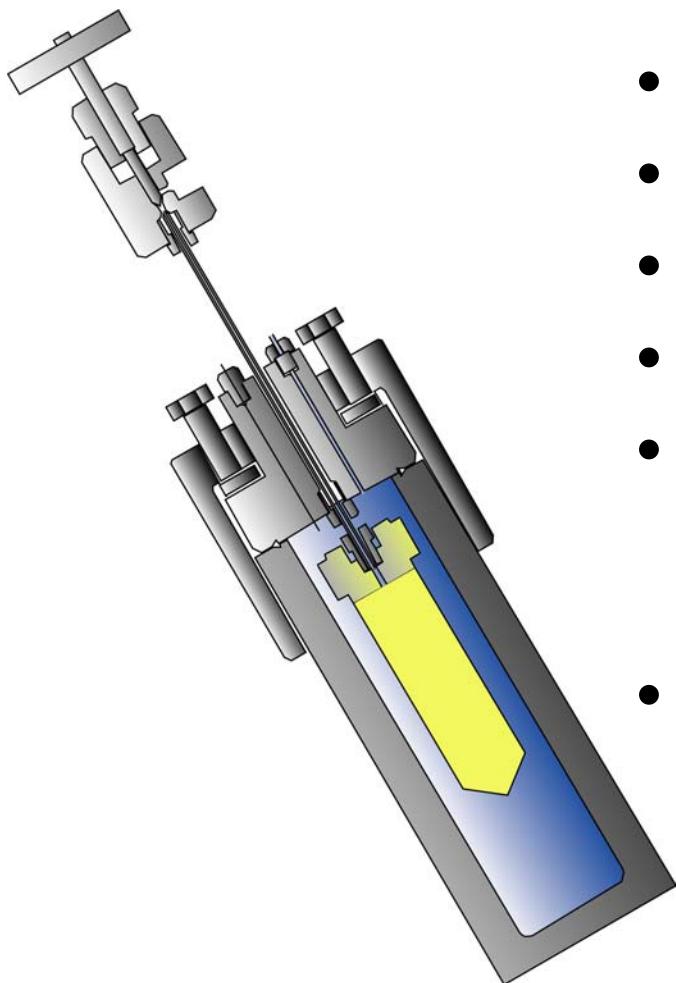
Kaszuba et al., 2003

Objectives for this Study

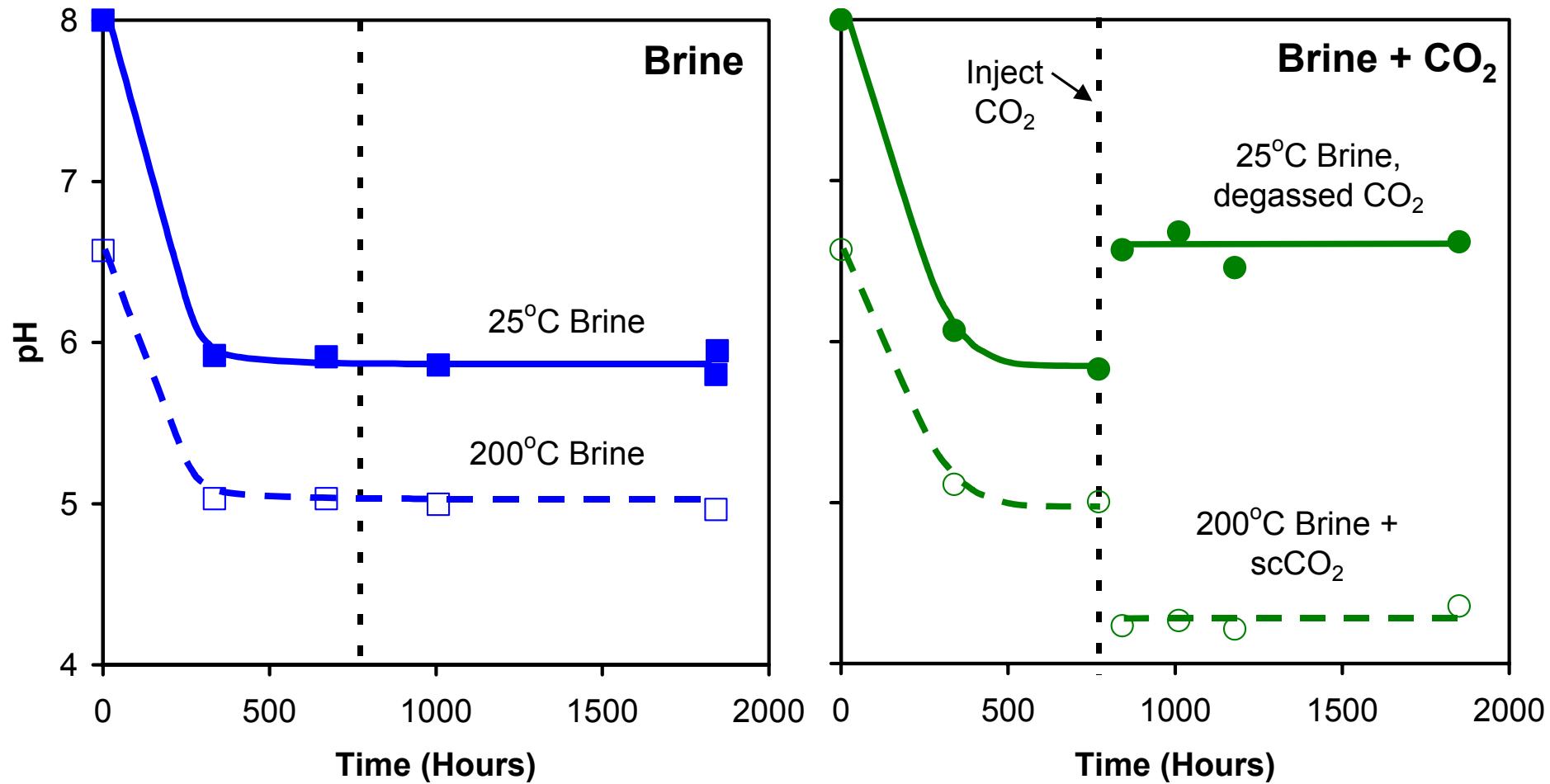
- Experimentally examine aquifer-aquitard-brine-supercritical CO₂ system that simulates geologic storage and sequestration of carbon dioxide
- Can geochemical reactions lead to failure modes in a simulated carbon repository?
- Immiscible fluids apply to a broader range of geologic processes than previously explored.
- Reactive properties of supercritical CO₂ coexisting with H₂O have implications for geochemical processes that are not understood or appreciated in the broader geologic community.

Experimental Approach

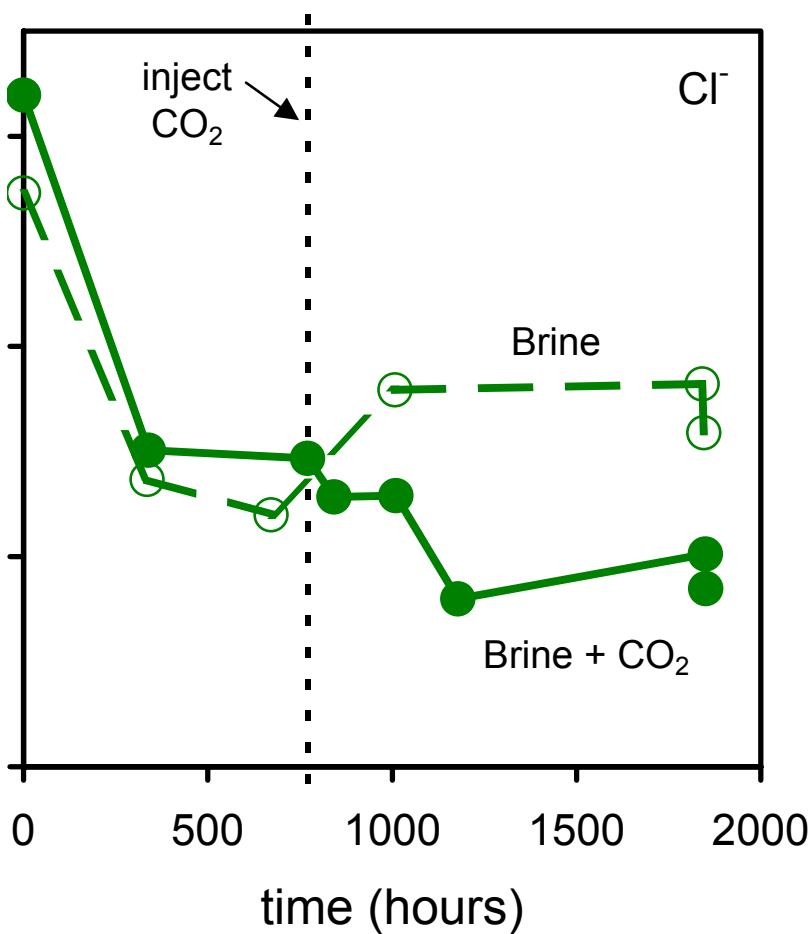
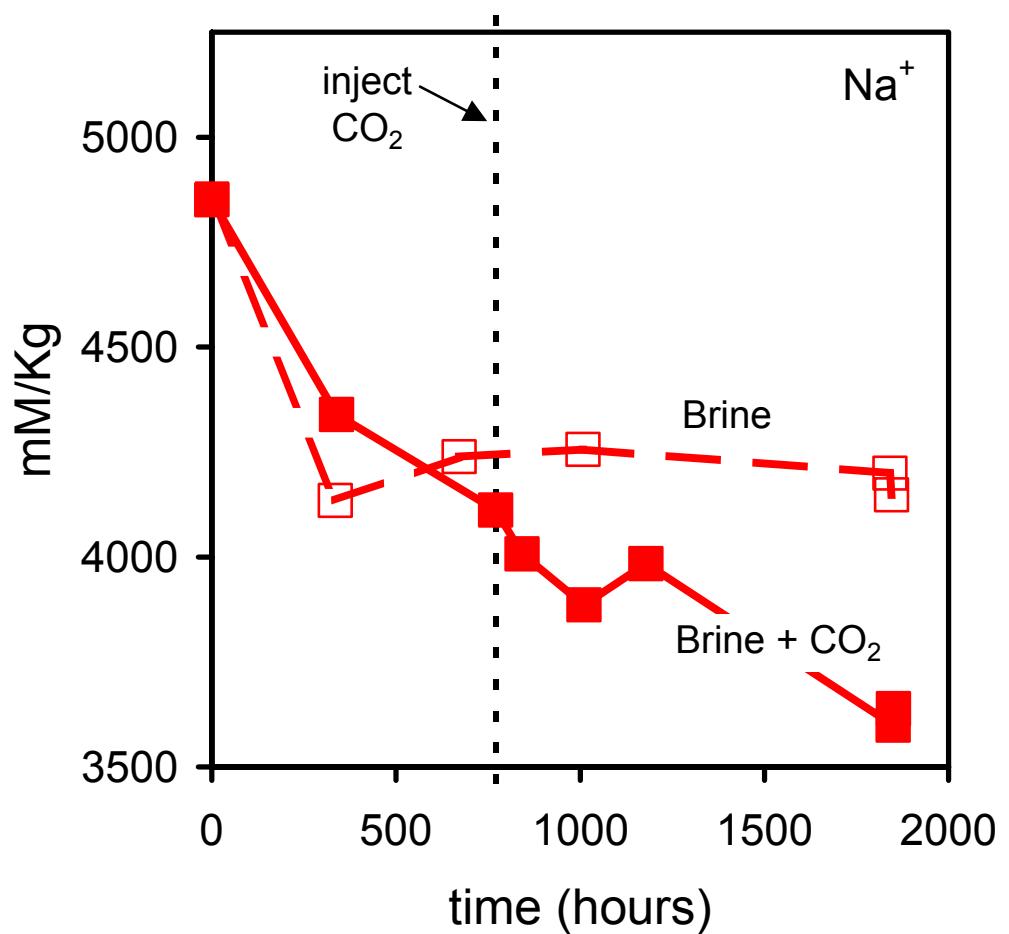
- Flexible cell hydrothermal apparatus
- 200°C and 200 bars
- 5.5 molal NaCl brine
- Aquifer = model arkose
- Aquitard = argillaceous shale
- Experiment
 - Brine + rock for 32 days
 - Inject CO₂ into ongoing reaction, 45 days
- Control Experiment
 - Brine + rock for 77 days



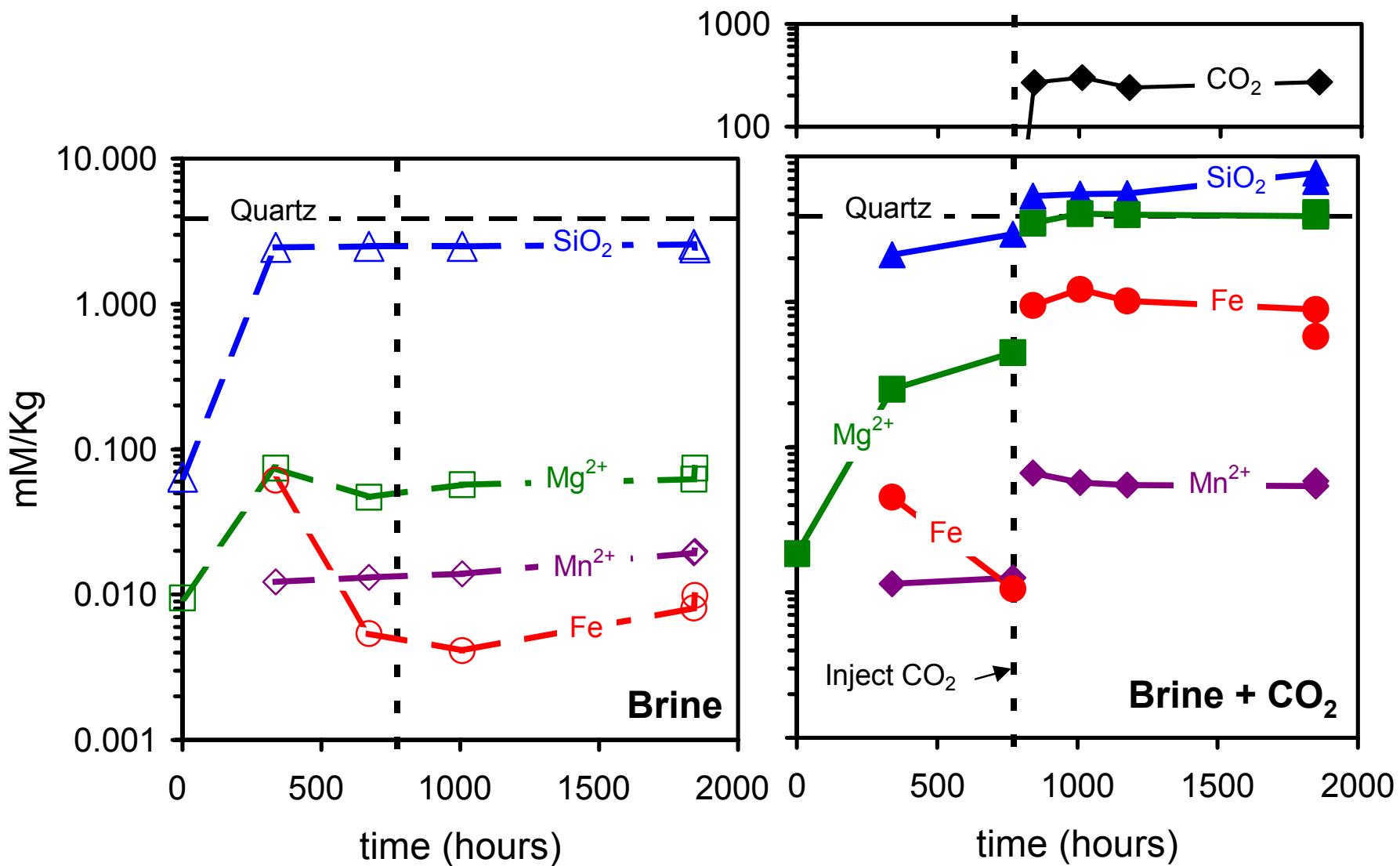
Brine Chemistry - pH



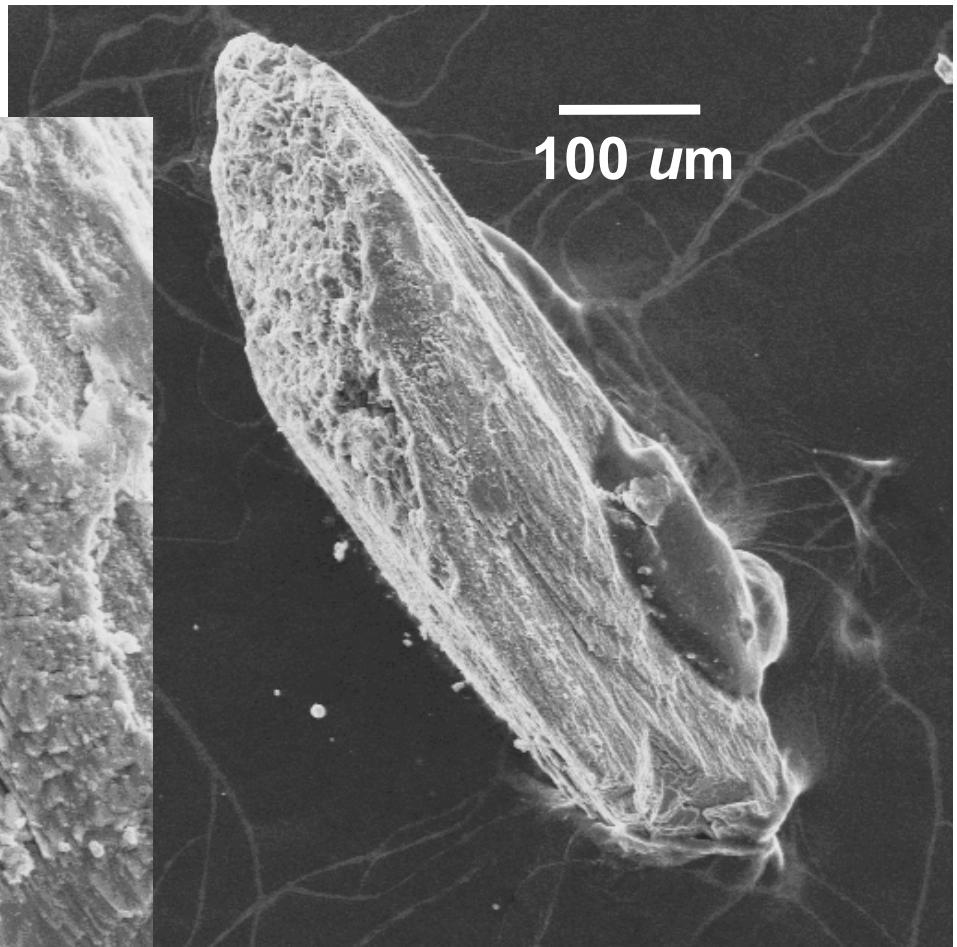
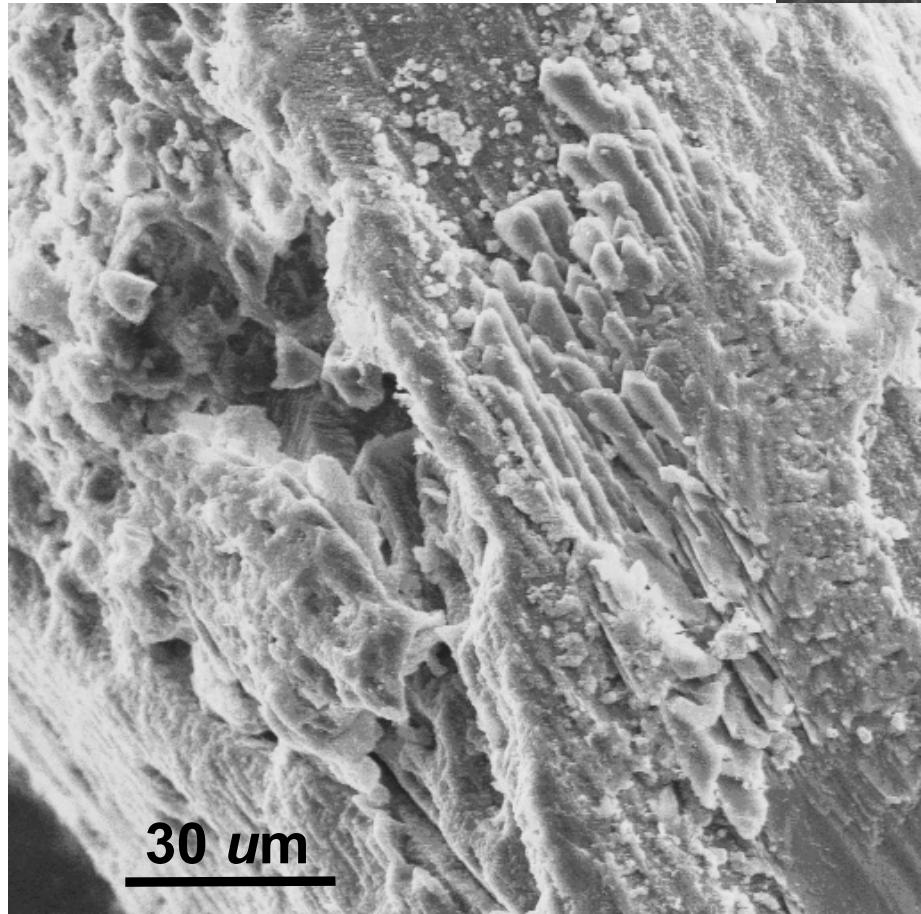
Brine Chemistry – Na and Cl



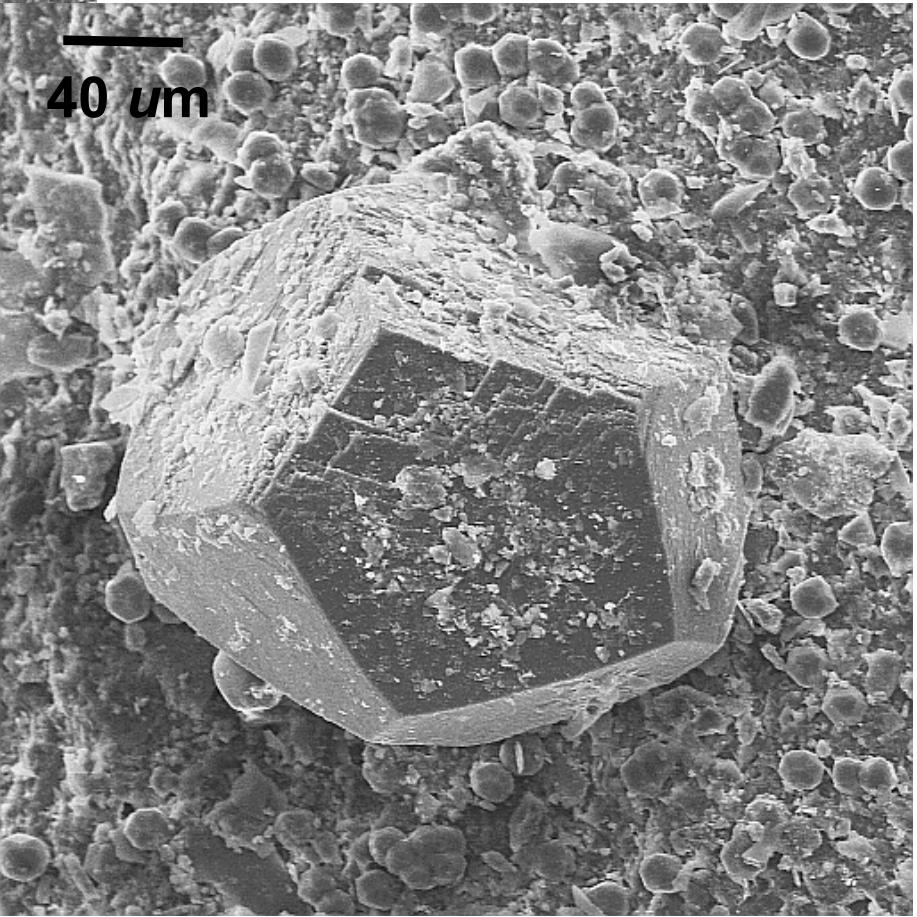
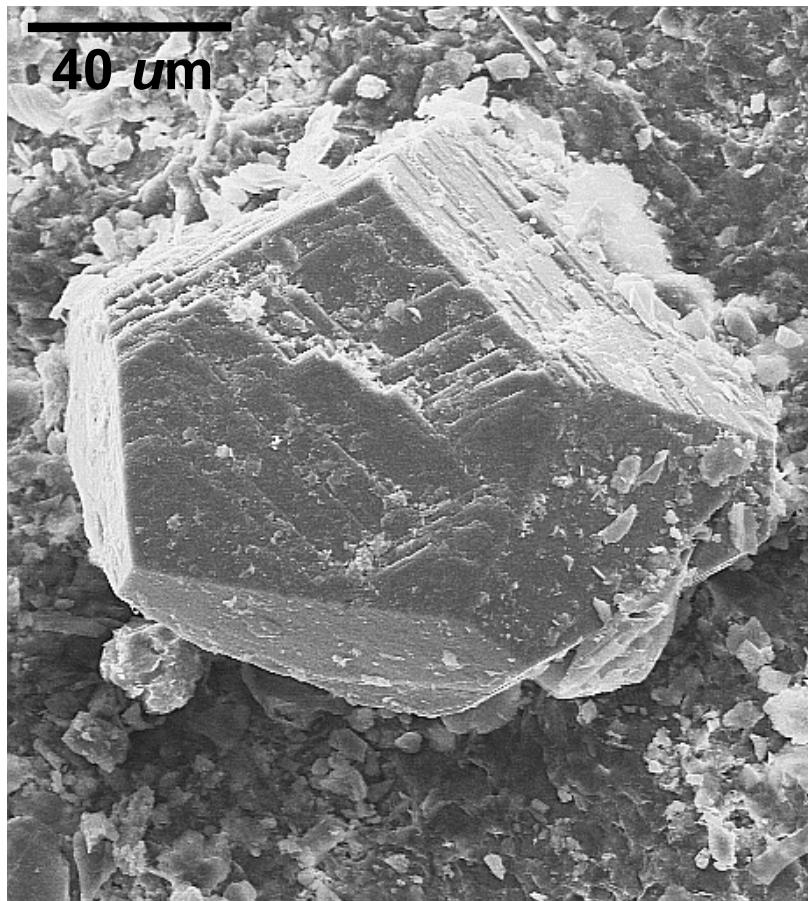
Brine Chemistry – Other Cations and CO₂



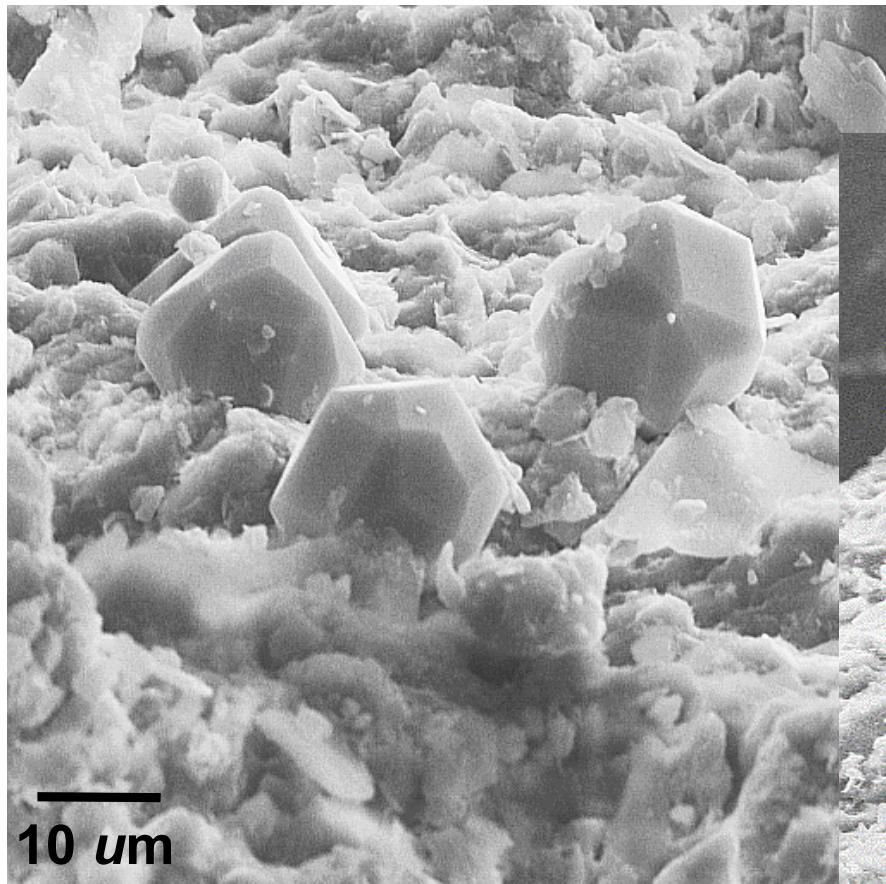
New Phase - Magnesite (CO₂-bearing Exp't)



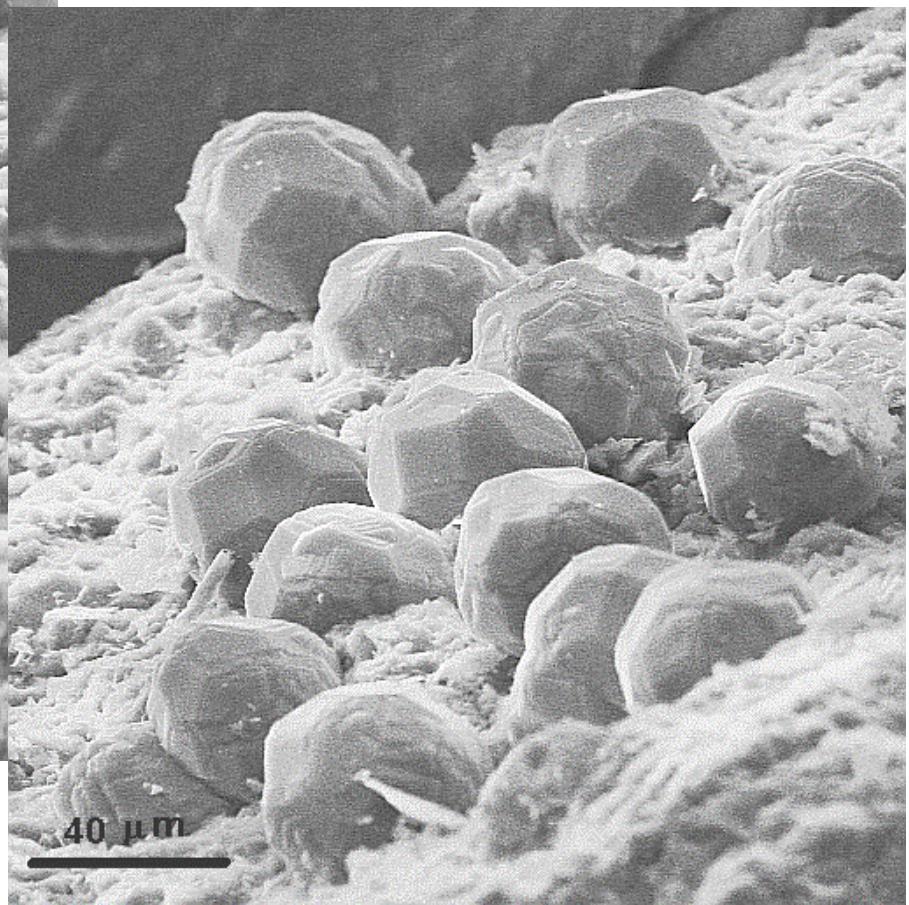
New Phase - Siderite (CO_2 -bearing Experiment)



New Phase - Euhedral Analcime

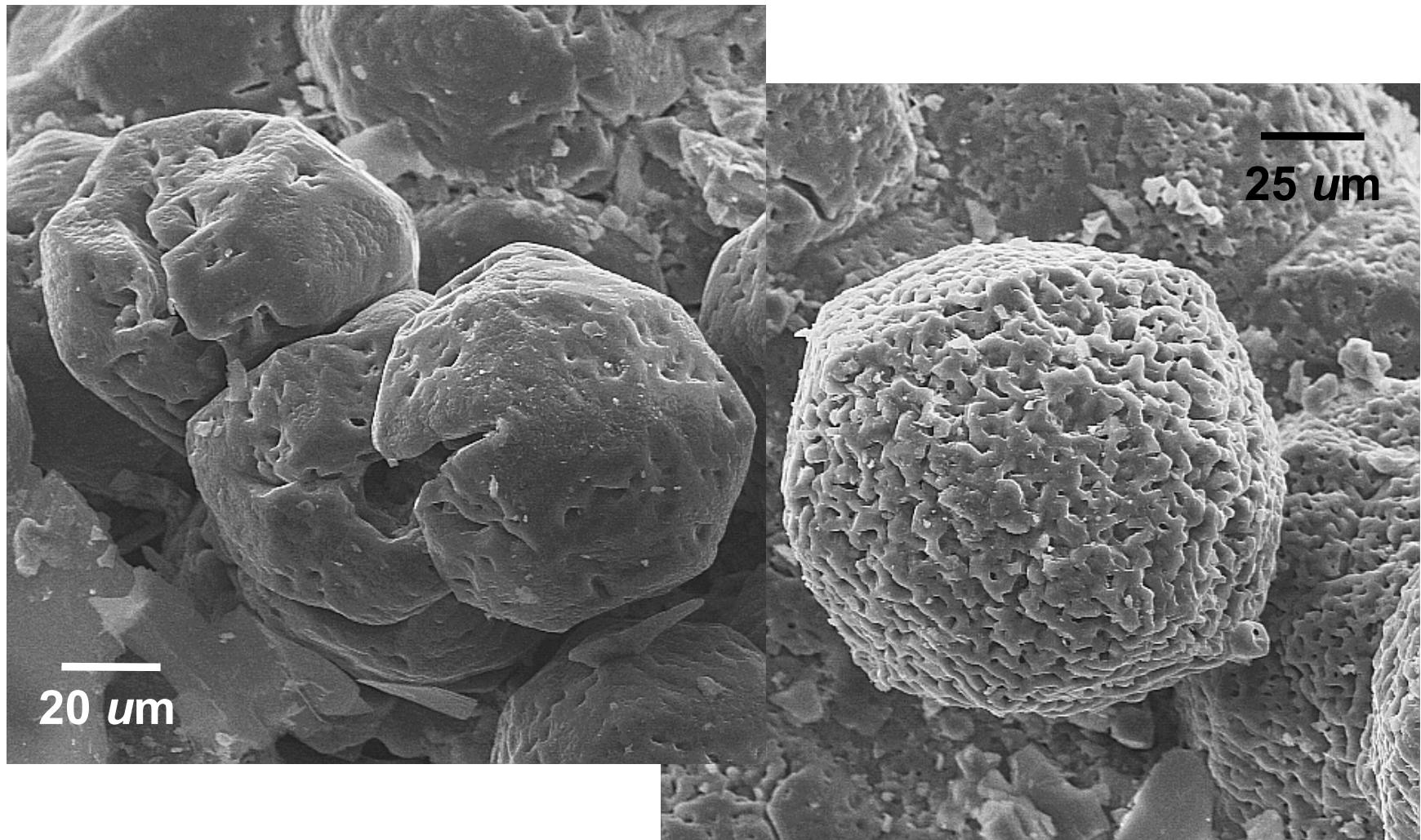


CO₂-absent Experiment

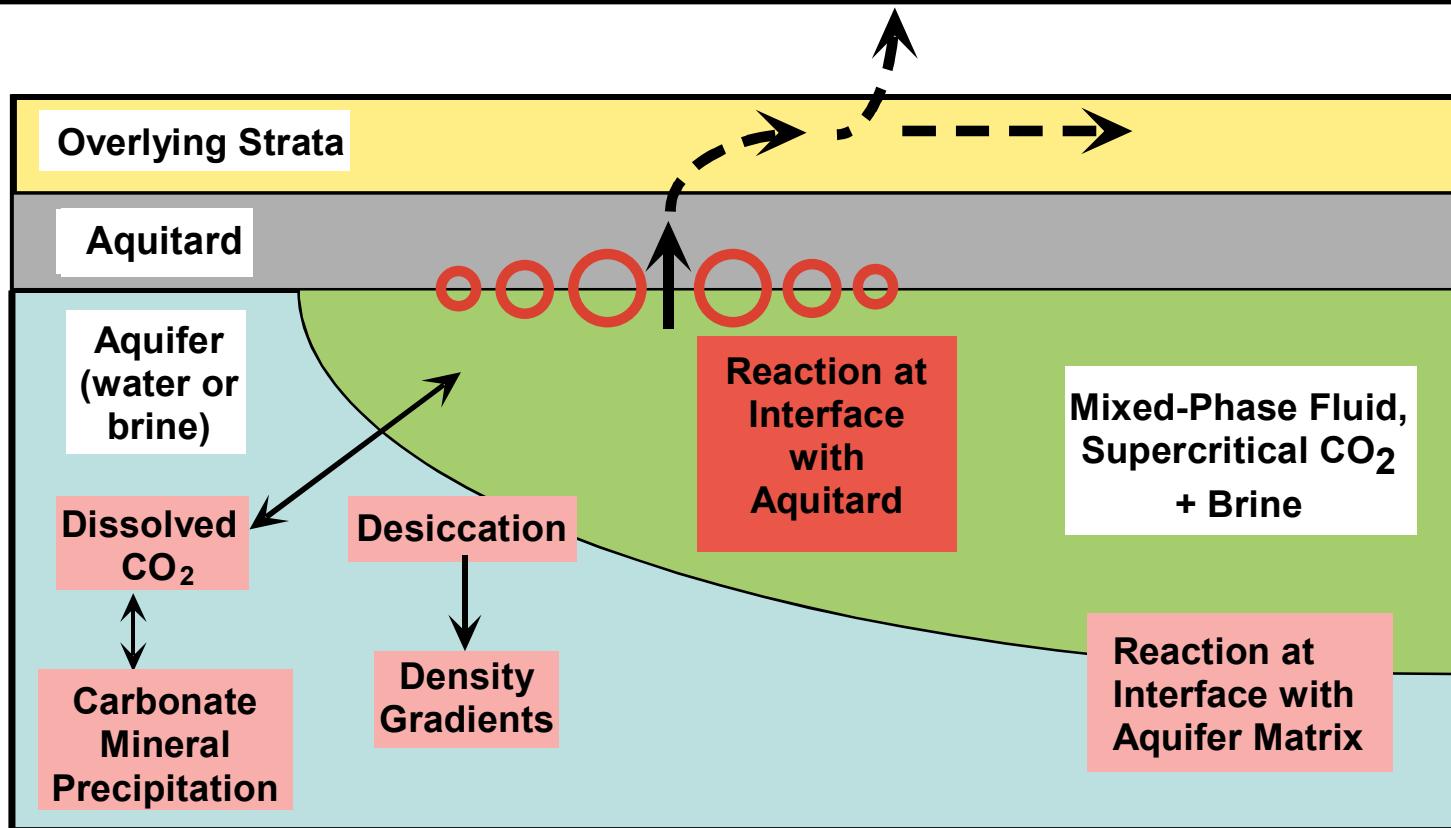


CO₂-bearing Experiment

New Phase - Skeletal Analcime (CO_2 -bearing)

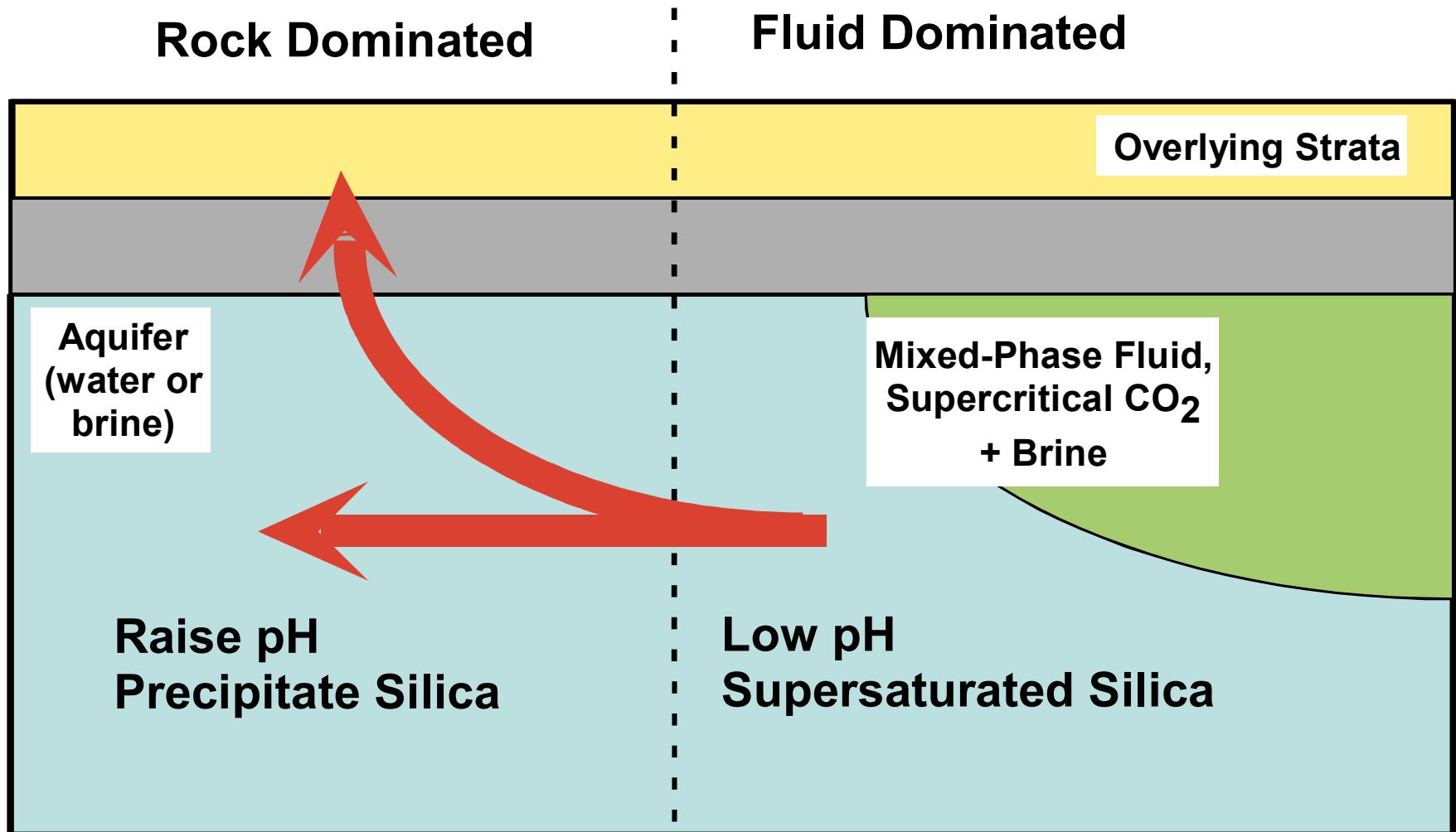


Conclusions - Geologic Sequestration of CO₂



- Complex (non-intuitive) geochemical reaction environment. Includes immiscibility & non-carbonates. Defies simplistic assumptions & predictions
- Aquitard (shale) reacts. What coupled chemical/physical changes are important for understanding failure modes?

Conclusions - Geologic Sequestration of CO₂



Applications and Acknowledgements

- Applications
 - Geologic CO₂ sequestration
 - Petroleum CO₂ flood recovery systems
 - Low-grade metamorphism
- Acknowledgements
 - US DOE BES Geoscience Program
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